ALABAMA PRISON ARTS + EDUCATION PROJECT

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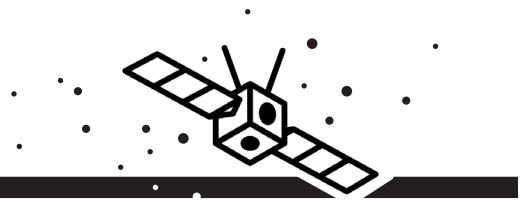
Dear Student, Artist, Thinker,

It's no wonder the fifth planet from the sun, **Jupiter**, was named after Jupiter, the king of all Roman Gods. As the largest planet in our solar system, Jupiter could house nearly 1,300 earths inside its gaseous interior. According to the Romans, the largest object in the sky must also be the most powerful. The Romans aren't chiefly known for their astronomy. But they stumbled on some truth concerning the wonderous nature of Jupiter, its mysteries, and its impact on our solar system.

There's so much to explore with Jupiter, from its moons to the cyclones at its poles, from its chemical composition to the electron showers of its upper atmosphere. Scientists are still learning more about this planet and its role in our solar system, and NASA continues to gather data and make discoveries about Jupiter using the Juno spacecraft, set to orbit Jupiter until 2025. Juno has helped scientists gain new insights regarding Jupiter's nature. Thermal imaging has led to new theories on the "giant weather systems caused by ammonia welling up from the deep atmosphere" and Jupiter's structure and magnetic field. Juno has helped scientists study the immense continent-sized cyclones at Jupiter's poles. At each pole, several cyclones rotate around a central cyclone, forming geometric patterns that never meet. No doubt it will take a long time to unravel all of Jupiter's mysteries. We can see why the Romans were so attracted to it.

But what would our solar system look like without Jupiter? Would our planet be bigger? Would it even exist? Some scientists theorize that Jupiter, due to its enormity and gravitational pull, may have had a hand in the early formation of our solar system. Other scientists look to Jupiter's moons, particularly Europa in hopes of discovering "an ocean of liquid water capable of hosting organic life" somewhere beneath its frozen surface. Maybe studying Jupiter and its moons will bring us one step closer to uncovering life on another planet — another orbiting home out there or a point of reference for future discovery about our own.

Selena, Colin, and Jess



"As soon as somebody demonstrates the art of flying, settlers from our species of man will not be lacking on the moon and Jupiter ... Given ships or sails adapted to the breezes of heaven, there will be those who will not shrink from even that vast expanse."

JOHANNES KEPLER // German mathematician, astronomer, and natural philosopher

WORDS INSIDE

FROM "UNCOVERING JUPITER'S ..."

optical | (in physics) operating in or employing the visible part of the electromagnetic spectrum

infrared | (of electromagnetic radiation) having a wavelength just greater than that of the red end of the visible light spectrum but less than that of microwaves. Infrared radiation is emitted particularly by heated objects

dynamical | characterized by continuous change, activity, or progress

inertia | (in physics) a property of matter by which it continues in its existing state of rest or uniform motion in a straight line, unless that state is changed by an external force

FROM "JUPITER, DESTROYER ..."

tack | (in sailing) to change course by turning a boat's head into and through the wind

• • •

THIS ISSUE WAS CURATED BY A FRIEND OF APAEP. GUEST CURATORS INCLUDE INSTRUCTORS, TUTORS, FRIENDS, AND LEARNERS WHO ARE PART OF THE BROADER APAEP COMMUNITY (FOR WHOM WE ARE GRATEFUL)!

TECHNOLOGY

Uncovering Jupiter's Secrets

BY LAUREN FUGE | *Cosmos Magazine* | March 7, 2018

Massive amounts of new data gathered by NASA's Juno spacecraft have drawn back the veils on Jupiter's cloudy surface, revealing unparalleled insights into the planet's mysterious depths and the continent-sized cyclones at its poles.

In a suite of four papers published this week in the journal *Nature*, an international team of astronomers reports Juno's new findings about Jupiter's gravitational field, atmospheric flows, interior composition and polar cyclones. These discoveries solve an almost 50-year-old puzzle in planetary science — what goes on beneath the planet's swirling clouds.

Although Jupiter's surface has been studied extensively, its interior remained unexplored until 2016, when Juno successfully slid into orbit around the gas giant. According to Tristan Guillot, one of the lead authors from the Observatoire de la Cote d'Azur in France, astronomers previously didn't know whether gaseous planets like Jupiter, Saturn and giant exoplanets rotate "with zones and belts all the way to the centre, or whether on the contrary the atmospheric patterns are skin-deep."

To tackle this question, Juno measured Jupiter's gravitational field. The team expected the winds in Jupiter's interior to be affected by the planet's density distribution, similar to how winds on Earth are caused by low- and high-pressure areas. Changes in density in turn cause the planet's gravitational field to fluctuate.

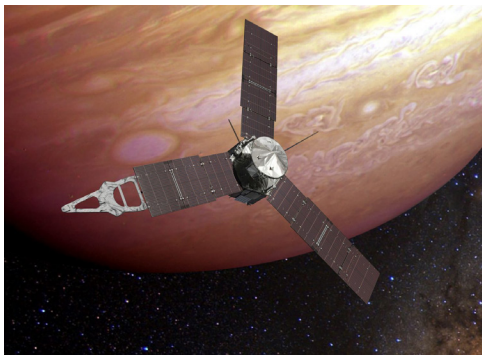
Alan Duffy, an astrophysicist from the Swinburne University of Technology in Australia, who was not part of the research team, explains: "As the spacecraft orbits it builds up a map of regions that pull more strongly than others. The data can then be split into spherical harmonics or moments, similar to the notes on a drum, that trace out the scale and type of the gravitating Structure beneath."

This technique allowed Luciano Iess from the Sapienza Università di Roma in Italy and colleagues to measure Jupiter's gravitational field 100 times more accurately than before. They showed that the field changes from the north to the south pole. This "north-south asymmetry" is driven by powerful flows of gas in the atmosphere and the interior. The deeper the winds go, the larger the asymmetry.

Two further papers used these results to show that the wind flows extend 3000 kilometres below the cloud tops — much deeper than previously expected.

"It's like going from a 2D picture to a 3D one," says Yohai Kaspi from the Weizmann Institute of Science in Israel, lead author of one paper. "This is important for understanding the nature and possible mechanisms driving these strong jet streams."

Kaspi's team also calculated that Jupiter's atmosphere makes up 1% of the planet's total mass. In comparison, the Earth's atmosphere is less than one millionth of our planet's mass.



Guillot and co-authors confirmed the depth of the wind flows by using models to interpret Juno's gravity measurements. They further discovered that the planet's deep interior is composed of a liquid mixture of hydrogen and helium that acts like a solid.

According to Guillot, this means 99% of Jupiter's mass "rotates uniformly — rather than with zones and belts rotating at differential speeds as in the atmosphere."

The fourth and final paper, led by Alberto Adriani from INAF–Istituto di Astrofisica e Planetologia Spaziali in Italy, reports that the continent-sized cyclones at Jupiter's poles — discovered by Juno last year — are not a chaotic jumble, but instead form polygonal patterns.

Using optical and infrared observations, the team found eight cyclones rotating around a single central cyclone at Jupiter's north pole, while at the south pole five such circumpolar cyclones dance around a central one.

How these structures formed and how they continue to survive without merging are still open questions.

But the research is far from over. Juno will continue to gather data until July 2018. Next, Iess says, the spacecraft "is set to measure tides raised by Io and the other moons, which may provide new insight into dynamical phenomena ongoing inside Jupiter."

The team also aims to use Juno to further study the Great Red Spot, the jet streams, and to measure the planet's moment of inertia to find out more about the variations in density. This same measurement was performed on Saturn just nine months ago by the Cassini spacecraft, giving scientists the opportunity to compare the two planets.

These new insights will go a long way towards building a better understanding of gas giant planets, including those in distant solar systems. ●

Edited for space

SCIENCE

Jupiter's 'Veiny Eyeball' Moon Europa is Spewing Water Into Space. Will it Taste of Life?

BY JAMIE CARTER | Forbes.com | May 14, 2020

Jupiter's fourth largest of its 79 moons, Europa, is more like a planet than a moon.

About 1,900 miles/3,100 kilometers in diameter, it's smaller than our own Moon, but larger than dwarf planet Pluto. It's got a thin oxygen-rich atmosphere. Europa has a layered inner structure including a liquid iron core, and a magnetic field. It looks like a "veiny eyeball" thanks to fractures in its icy surface.

It's also got water.

Scientists have long known that Europa has a global ocean of water beneath an 11 mile/18-kilometer-thick crust of ice.

Could it host simple forms of alien life? It's a high-priority target of investigation for space agencies.

If scientists could sample Europa's water, they could potentially discover extraterrestrial life for the first time. But landing a probe and drilling through the ice isn't going to happen anytime soon.

Which is why it's so exciting that yet another group of scientists think a 20-year-old NASA space probe may have already witnessed Europa spew a plume of water from that ocean into space.

Could a couple of space probes — both due to launch in a few years in any case — fly through Europa's water plumes and detect signs of extraterrestrial life?

A new paper published this week in *Geophysical Research Letters* argues that NASA's space probe Galileo — which orbited Jupiter between 1995 to 2003, and discovered hints of a subsurface ocean on Europa — may have also collected evidence that the moon occasionally releases some of this water into space.

By using computer simulations and new calculations, a group of researchers at the European Space Agency (ESA) and the Max Planck Institute for Solar System Research (MPS) reproduced data gathered by Galileo's onboard Energetic Particles Detector (EPD) by modeling the movements of high-energy protons around Europa during the flyby.

Their results — which include changes to high-energy protons in Jupiter's magnetic field near the moon — can be explained by the presence of plumes of water. Previously, researchers had assumed the moon itself to have obstructed the detector's view.

The plumes are less spouts of water and more like "cryovolcanic eruptions" — ice volcanoes — that spew liquid instead of molten rock. Neptune's moon Triton and Pluto's moon Charon are known to display similar behavior.

The Galileo spacecraft itself was sacrificed in 2003 to protect Europa's ocean; NASA did not want risk the spacecraft crashing into Europa and contaminating it just in case it does host simple life.

Mounting evidence

Conclusive proof that also Europa spews water into space is still missing, but the study is another piece of evidence. In 2012 the Hubble Space Telescope detected hydrogen and oxygen in Europa's atmosphere, and in 2016 it imaged what may be water vapor plumes erupting off the surface.

Europa is the fourth-largest moon of Jupiter. On the left is a view of Europa taken from 2.9 million kilometers (1.8 million miles) away on March 2, 1979 by the Voyager 1 spacecraft. Next is an image of Europa taken by the Voyager 2 spacecraft during its close encounter on July 9, 1979. On the right is a view of Europa made from images taken by the Galileo spacecraft in the late 1990s.

NASA/JPL-Caltech/ SETI Institute

What is the Jupiter Icy Moons Explorer (JUICE) mission?

Set to launch in 2020, the European Space Agency's JUpiter ICy moons Explorer (JUICE) will spend three and a half years examining Europa and two of Jupiter's other large moons, Ganymede and Callisto. Its cameras and ice-penetrating radar will be used to study the composition of Europa's icy crust, detecting whether there are reservoirs of water between layers of ice.

What is the Europa Clipper mission?

Scheduled to launch in 2023, NASA's Europa Clipper mission will perform about 45 flybys, in each pass photographing the moon's icy surface in high resolution.

Both probes could now have a flight plan that has them fly through the plumes of water vapor erupting from Europa's ice crust, thereby sampling its subsurface ocean.

That would be way, way easier — and much quicker — that having to design and send a mission that could land on Europa's surface and drill through the ice. ●

MATHEMATICS

Sudoku

#147 PUZZLE NO. 2080225

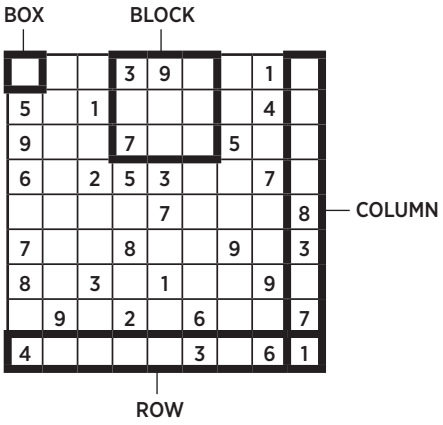
				5			2	
		7		1	4			
				9	3	6		7
			6					9
		4			2			
		2					5	
	4		1					3
9	8						4	
	1	3	4		8			

#148 PUZZLE NO. 2921540

	5		8				6	
1			2					7
				4			9	
7		9						8
6								5
	8		1			4		6
		8		6				4
	9		5	7				
5	6	2		8				

SUDOKU HOW-TO GUIDE

1. Each block, row, and column must contain the numbers 1–9.
2. Sudoku is a game of logic and reasoning, so you should not need to guess.
3. Don't repeat numbers within each block, row, or column.
4. Use the process of elimination to figure out the correct placement of numbers in each box.
5. The answers appear on the last page of this newsletter.



What the example will look like solved

2	4	8	3	9	5	7	1	6
5	7	1	6	2	8	3	4	9
9	3	6	7	4	1	5	8	2
6	8	2	5	3	9	1	7	4
3	5	9	1	7	4	6	2	8
7	1	4	8	6	2	9	5	3
8	6	3	4	1	7	2	9	5
1	9	5	2	8	6	4	3	7
4	2	7	9	5	3	8	6	1

"Our best shot at finding life in our solar system might be to look at the moons of Jupiter and Saturn. Mars, increasingly, looks like a dead planet. But the oceans beneath the ice cover of the moons of Jupiter and Saturn may actually have more liquid water than the oceans of Earth."

MICHIO KAKU // American theoretical physicist and futurist

Icons from the Noun Project

DID YOU KNOW?

Jupiter is the **fourth brightest** object in the solar system. Only the Sun, Moon and Venus are brighter. It is one of five planets visible to the naked eye from Earth.

The ancient **Babylonians were the first to record their sightings** of Jupiter. This was around the 7th or 8th century BC. Jupiter is named after the king of the Roman gods. To the Greeks, it represented Zeus, the god of thunder. The Mesopotamians saw Jupiter as the god Marduk and patron of the city of Babylon. Germanic tribes saw this planet as Donar, or Thor.

Jupiter has the **shortest day** of all the planets. It turns on its axis once every 9 hours and 55 minutes. The rapid rotation flattens the planet slightly, giving it an oblate shape.

Jupiter has unique cloud features. The upper atmosphere of Jupiter is **divided into cloud belts and zones**. They are made primarily of ammonia crystals, sulfur, and mixtures of the two compounds.

Jupiter's interior is made of **rock, metal, and hydrogen compounds**. Below Jupiter's massive atmosphere (which is made primarily of hydrogen), there are layers of compressed hydrogen gas, liquid metallic hydrogen, and a core of ice, rock, and metals.

Source: https://space-facts.com/jupiter/

"The first mission to Mars did not expect to find craters and river valleys, and yet they did. The first mission to Jupiter didn't expect to find ocean worlds and volcano worlds, but they did."

ALAN STERN // American engineer and planetary scientist

Idiom

"Worlds apart"

Meaning Greatly separated by differing attitudes, needs, opinions, or temperaments.

Origin Scholars are not certain of the origin of the idiom "worlds apart." The term is closely related to the late 13th century Latin *distantia*, which is an expression of remoteness or a "standing apart." By the late 14th century, the figurative meaning of remoteness grew to include space between places or things, which is essentially the same meaning as the more modern idiom "worlds apart."

Source: gingersoftware.com

THE GREAT RED SPOT IS A **HUGE STORM** ON JUPITER. IT HAS RAGED FOR AT LEAST 350 YEARS. IT IS SO LARGE THAT THREE EARTHS COULD FIT INSIDE IT.

JUPITER'S MOON **GANYMEDE IS THE LARGEST MOON** IN THE SOLAR SYSTEM. IT MEASURES 5,268 KM ACROSS, MAKING IT LARGER THAN THE PLANET MERCURY.

ART + CULTURE

Planet

BY CATHERINE PIERCE

This morning this planet is covered by winds and blue.
This morning this planet glows with dustless perfect light,
enough that I can see one million sharp leaves
from where I stand. I walk on this planet, its hard-packed

dirt and prickling grass, and I don't fall off. I come down
soft if I choose, hard if I choose. I never float away.
Sometimes I want to be weightless on this planet, and so

I wade into a brown river or dive through a wave
and for a while feel nothing under my feet. Sometimes
I want to hear what it was like before the air, and so I duck
under the water and listen to the muted hums. I'm ashamed

to say that most days I forget this planet. That most days
I think about dentist appointments and plagiarists
and the various ways I can try to protect my body from itself.

Last weekend I saw Jupiter through a giant telescope,
its storm stripes, four of its sixty-seven moons, and was filled
with fierce longing, bitter that instead of Ganymede or Europa,
I had only one moon floating in my sky, the moon

called Moon, its face familiar and stale. But this morning
I stepped outside and the wind nearly knocked me down.
This morning I stepped outside and the blue nearly

crushed me. This morning this planet is so loud with itself—
its winds, its insects, its grackles and mourning doves—
that I can hardly hear my own lamentations. This planet.
All its grooved bark, all its sand of quartz and bones

and volcanic glass, all its creeping thistle lacing the yards
with spiny purple. I'm trying to come down soft today.
I'm trying to see this place even as I'm walking through it.

Catherine Pierce was born in Delaware. She is the author of *The Girls of Peculiar* (Saturnalia, 2012), which won the Mississippi Institute of Arts and Letters Poetry Prize.

Of her work, Aimee Nezhukumatathil writes, "With a jeweler's eye and anuncanny knack for embracing devastating truths and desires,Pierce rewrites what it means to sift through wreckage of both heart and land."Pierce codirects the creative writing program at Mississippi State University. She lives in Starkville, Mississippi.

WRITING PROMPT

It can be easy to overlook what we are used to — our own planet is a perfect example of that old adage, "When you are on the mountain, you can't see the mountain." But maybe this can serve as a creative door. Imagine characteristics you would select if you were to create your own planet — what does it look, feel, smell, and sound like? What does it mean for you? Create a poem or story in which you and your reader can be immersed in this personally-designed planet. Incorporate the things you forget, the things you remember, the things you long for. What is it that you gravitate towards, and how can you describe it in ways that pull your readers into your orbit? Go on your own space exploration of your world and what it signifies as you write. Show your imagined audience, there or here on earth, as much as you possibly can.

Word Search

V	Z	G	R	A	S	B	W	B	H	Z	W	S	L
E	U	E	G	D	A	E	A	A	G	E	S	I	E
W	P	V	G	I	S	V	V	T	E	E	C	M	P
E	S	O	A	N	R	R	E	P	L	I	O	F	L
P	S	L	C	C	I	V	P	T	W	I	N	D	A
E	A	C	A	S	D	T	H	G	I	A	N	T	N
R	R	A	Q	R	E	G	A	A	T	A	V	N	E
F	G	N	V	U	I	L	C	O	P	I	T	O	T
E	B	I	T	E	A	E	E	O	L	Y	O	V	W
C	R	C	W	M	L	R	R	T	K	F	T	E	E
T	O	G	E	E	U	U	T	S	N	O	O	M	E
O	W	S	M	B	E	T	P	Z	S	T	O	R	M
S	N	N	R	E	C	R	E	I	F	L	S	E	A
N	G	F	I	E	L	O	F	D	I	O	T	L	K

FIERCE
VOLCANIC
EUROPA
WAVE
MUTED
GRASS
MOON
FLOATING
GIANT
STORM
BROWN
WIND
QUARTZ
PLANET
WEIGHTLESS
PERFECT
TELESCOPE
SKY

CLIMATE

Huge New Storm Creates Hexagon at Jupiter's South Pole

BY MIKE WALL | Space.com | December 14, 2019

SAN FRANCISCO — NASA's Juno probe discovered a giant new storm swirling near Jupiter's south pole last month, a few weeks after pulling off a dramatic death-dodging maneuver.

Juno spied the newfound maelstrom, which is about as wide as Texas, on Nov. 3, during its most recent close flyby of Jupiter. The storm joins a family of six other cyclones in Jupiter's south polar region, which Juno had spotted on previous passes by the gas giant. (Those encounters also revealed nine cyclones near Jupiter's north pole, by the way.)

The southern tempests are arrayed in a strikingly regular fashion. Previously, five of them had formed a pentagon around a central storm, which is as wide as the continental United States. With the new addition, that girdling structure is now a hexagon.

"These cyclones are new weather phenomena that have not been seen or predicted before," Cheng Li, a Juno scientist from the University of California, Berkeley, said in a statement yesterday (Dec. 12).

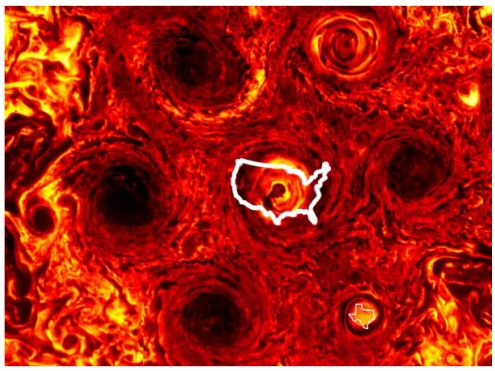
"Nature is revealing new physics regarding fluid motions and how giant planet atmospheres work," he added. "We are beginning to grasp it through observations and computer simulations. Future Juno flybys will help us further refine our understanding by revealing how the cyclones evolve over time."

Juno orbits Jupiter on a highly elliptical path every 53 Earth days, gathering most of its data when it comes closest to the giant planet. And those encounters are quite close indeed: During the Nov. 3 pass, the 22nd science flyby of Juno's $1.1 billion mission, the probe skimmed a mere 2,175 miles (3,500 kilometers) above Jupiter's cloud tops, NASA officials said.

But it took some fancy flying to make sure Juno survived the experience. The mission team determined that the probe's trajectory would take Juno into Jupiter's shadow for 12 hours on Nov. 3. And that likely would've been a death sentence for the solar-powered probe.

"We would've gotten cold. Really, really cold," Juno project scientist Steve Levin, of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, said during a press conference here yesterday at the annual fall meeting of the American Geophysical Union (AGU), where the team announced the new results.

But the navigation team at JPL came up with a solution: "jumping Jupiter's shadow." On Sept. 30, Juno's handlers directed the solar-powered probe to fire its small reaction-control engines in pulses for 10.5 hours. This pushed the probe's path steadily outward — and, ultimately, out of the shadow path altogether, Levin explained.



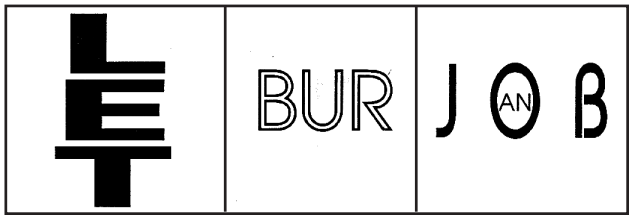
An outline of the continental United States superimposed over the central cyclone and an outline of Texas is superimposed over the newest cyclone at Jupiter's south pole give a sense of their immense scale. The hexagonal arrangement of the cyclones is large enough to dwarf the Earth.

Image by NASA/JPL-Caltech/SwRI/ASI/INAF/JIRAM

"Without that maneuver, without the creative genius of the folks at JPL on the navigation team, we wouldn't have the beautiful data that we have to show you today," he said.

Juno launched in 2011 and arrived in orbit around Jupiter on July 4, 2016. The spacecraft is studying Jupiter's composition and gravitational and magnetic fields, among other things. The data Juno is gathering should help researchers better understand how Jupiter — and, by extension, the solar system — formed and evolved, mission team members have said.

The initial mission plan called for Juno to tighten its science orbit considerably, down to 14 Earth days. But the team called off the engine burns that would have achieved this reduction after discovering issues with the probe's fuel-delivery system. So, Juno will stay in the 53-day orbit for the duration of its mission, which currently goes through July 2021. ●



WORD PLAY A Rebus puzzle is a picture representation of a common word or phrase. How the letters/images appear within each box will give you clues to the answer! For example, if you saw the letters "LOOK ULEAP," you could guess that the phrase is "Look before you leap." *Answers are on the last page!*

PHYSICS

Jupiter, Destroyer of Worlds, May Have Paved the Way for Earth

Careening toward the sun, Jupiter cleared the way for Earth to form — with help from Saturn, too

BY LEE BILLINGS | *Scientific American* | April 1, 2021

A new study suggests that without Jupiter, Earth itself might not exist. Where this and the other rocky planets now orbit there may have first been a previous generation of worlds destined to be bigger, gas-shrouded, utterly uninhabitable orbs. But Jupiter came swinging in, clearing the way for small worlds like Earth by destroying those older planets. The study, co-authored by California Institute of Technology planetary scientist Konstantin Batygin and University of California, Santa Cruz, astrophysicist Greg Laughlin, appeared in the March 23 *Proceedings of the National Academy of Sciences*.

Although our solar system is essentially empty inward of Mercury, equivalent regions around most other stars appear to be packed with close-in, intermediate-mass planets — those between the size of Earth and Neptune. Hopeful astronomers have dubbed these worlds "super-Earths" but most of them seem to be more like hydrogen-rich, gas-shrouded mini-Neptunes — very unearthly indeed. "Now that we can look at our own solar system in the context of all these other planetary systems," Laughlin says, "the standard-issue planetary system in our galaxy seems to be a set of super-Earths with alarmingly short orbital periods. Our solar system is looking increasingly like an oddball."

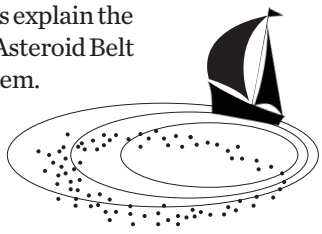
If so, the obvious question is how it got that way. According to Batygin, there's no reason to suspect that the actual process of planet formation occurred very differently around our sun than around other stars. Instead, the explanation for our solar system's outlier status may be found in the details of its subsequent evolution — controlled to a remarkable degree by Jupiter.

Migrating worlds

Twenty years ago when astronomers found the first planets orbiting other stars, they also began realizing that planetary systems are chaotic places. Some planets did not orbit in near-circles but in oblong "eccentric" paths that took them swinging close and then far from their stars — almost as if they had been thrown off-kilter by the gravitational influence of other worlds. And most of the newfound giant planets were very different than Jupiter — in scorching, star-hugging orbits far inward from the cold outer regions where they must have formed. Planets could migrate, too, propelled by gentle interactions with their formative disks or by close encounters with their planetary siblings.

Ever since those discoveries researchers have been grappling with the idea of planetary migration to better understand not only the features of other planetary systems, but our own. One example is the "grand tack" scenario, which posits that in the first few million years of our solar system's existence Jupiter migrated into and then back out of the inner solar system, following a course similar to a sailboat's when it tacks around a buoy. Back then Jupiter would have still been embedded in a gas-rich disk. Much of that gas was spiraling down toward the sun — so much that the action would have sapped some of Jupiter's angular momentum, too, causing the giant planet itself to spiral in to the vicinity of where Mars is today. Jupiter would have kept falling in toward the sun if not for being caught by the subsequent formation of Saturn, which began drifting in as well. As the two giant planets came closer together, they were caught in an orbital resonance. This resonance expelled all the gas between them, gradually reversing their death spirals and causing them to "tack" back out to the outer solar system.

As outlandish as it seems, the physical mechanisms underlying the grand tack hypothesis are sound and there are good reasons to suspect it took place. The scenario neatly explains Mars's anomalously small size, which theorists believe should be larger, given how much planet-forming material should have existed long ago in its orbit. In the grand tack Jupiter would have ejected most of that material, leaving behind just enough for Mars to form. The hypothesis also helps explain the distribution of icy and rocky bodies in the Asteroid Belt and various other features of the solar system.



The grand attack

In their study Batygin and Laughlin investigated whether Jupiter's grand

tack could explain the gaping hole at the heart of our solar system, too. Numerical simulations suggested that Jupiter's inward spiral would send swarms of 100-kilometer-wide planetary building blocks cascading into the inner solar system. The giant planet's gravity would also sling those building blocks and the inner planets themselves into overlapping, elliptical orbits, creating an interplanetary demolition derby of whirling, colliding fragmenting worlds. "It's the same thing we worry about if satellites were to be destroyed in low Earth orbit," Laughlin says. "Their fragments would start smashing into other satellites and you'd risk a chain reaction of collisions. Our work indicates that Jupiter would have created just such a collisional cascade in the inner solar system."

Although these collisions would have been spectacularly violent, they could not by themselves entirely destroy the coalescing super-Earths. Instead, the avalanche of debris from the collisions would have raised powerful aerodynamic headwinds in the surrounding solar system disk, forming spiraling swirls of gas that then swept the first generation of inner rocky planets down into the sun. "It's a very effective physical process," Batygin says. "You only need a few Earth masses worth of material to drive tens of Earth masses worth of planets into the sun."

Beyond observations of other planetary systems suggesting that ours is an outlier, there is scant evidence that our sun formed and lost an earlier generation of inner worlds. But Laughlin finds the technical strength and sweetness of the idea compelling. "This kind of theory, where first this happened and then that happened, is almost always wrong, so I was initially skeptical," he says. "But it actually involves generic processes that have been extensively studied by other researchers ... Jupiter's 'grand tack' may well have been a 'grand attack' on the original inner solar system."

A lonelier planet

After Jupiter's grand attack, only whiffs of volatile gas and dregs of shattered rock would remain, but Batygin notes that only about 10 percent of the total material Jupiter may have injected into the inner solar system would have been required to form Mercury, Venus, Earth and Mars. As Jupiter reversed its course and spiraled back to the outer solar system, its passage could have settled a fraction of the dregs into more circular orbits. Across a span of one hundred million to two hundred million years those meager, volatile-depleted dregs would then glom together to make the relatively small and arid inner planets we know today. All this is consistent with a wealth of other evidence suggesting the inner rocky planets formed significantly later than the outer giants, and explains why the sun's inner worlds are smaller and have thinner atmospheres than those observed around other stars.

The picture that emerges is that we may be even more cosmically alone than previously appreciated. "One of the predictions of our theory is that truly Earth-like planets, with solid surfaces and modest atmospheric pressures, are rare," Laughlin says.

If true, Batygin and Laughlin's study would mean that the vast majority of close-in, potentially rocky and habitable planets we now observe around so many other stars may not turn out to be rocky or habitable at all. Instead, visiting them you'd be crushed, cooked and smothered beneath their thick hydrogen-rich atmospheres. The study also suggests that far-out Jupiters are very uncommon around other stars; rather than only briefly visiting inner systems, most giant planets would migrate there to stay, potentially precluding the formation of Earth-like worlds. ●

Edited for space

RANDOM-NEST

How Did the Planets Get Their Names?

BY THE STARCHILD TEAM | StarChild.gsfc.nasa.gov | August 2002

Mercury is the god of commerce, travel and trickery in Roman mythology. The planet probably received this name because it moves so quickly across the sky.

Venus is the Roman goddess of love and beauty. The planet is aptly named since it makes a beautiful sight in the sky, with only the Sun and the Moon being brighter.

Earth is the only planet whose English name does not derive from Greek/Roman mythology. The name derives from Old English and Germanic. There are, of course, many other names for our planet in other languages.

Mars is the Roman god of war. The planet probably got this name due to its red color.

Jupiter was the king of the gods in Roman mythology, making the name a good choice for what is by far the largest planet in our solar system.

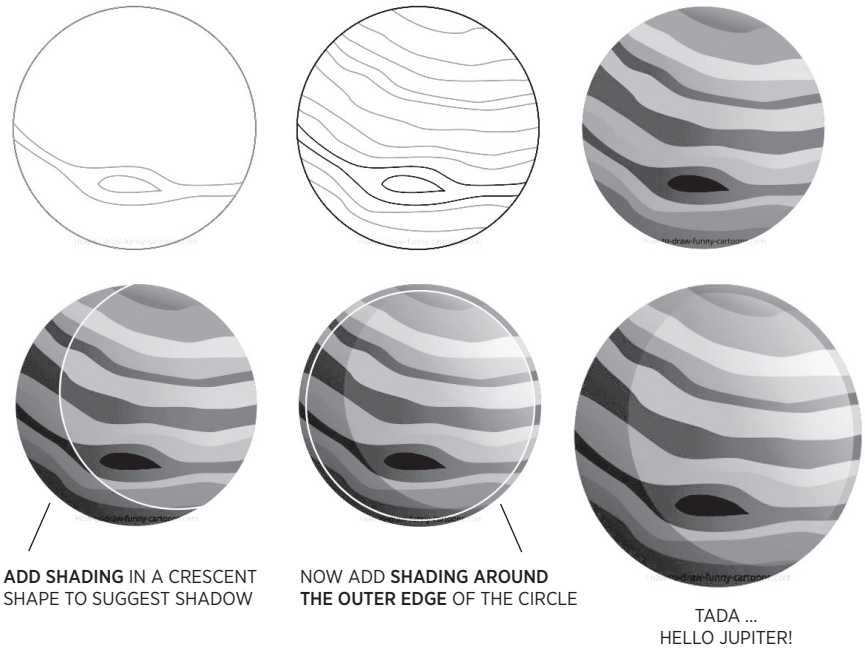
Saturn is the Roman god of agriculture.

Uranus is the ancient Greek deity of the Heavens, the earliest supreme god.

Neptune, was the Roman god of the sea. Given the beautiful blue color of this planet, the name is an excellent choice!

While no longer considered a planet, **Pluto** is the Roman god of the underworld in Roman mythology. Perhaps the planet received this name because it's so far from the Sun that it is in perpetual darkness.

HOW TO DRAW JUPITER



ADD SHADING IN A CRESCENT SHAPE TO SUGGEST SHADOW

NOW ADD **SHADING AROUND THE OUTER EDGE** OF THE CIRCLE

TADA ...
HELLO JUPITER!

WORDS OF ENCOURAGEMENT

I've lately learned to value the power of taking note of the little things, of opening my eyes to the potential in every idea and thing I encounter. I often fail to see the exciting discoveries offered in my own life, especially when times get tough. When I take a moment to zoom *in*, I see my journey through eyes fine-tuned to notice the intricacies of my personal and creative weather.

Ansel Adams, American landscape photographer, once said, "In wisdom gathered over time I have found that every experience is a form of exploration." We don't need telescopes or rocket ships to go on our own space exploration, to make exhilarating revelations — we are always in orbit with reflective surfaces gliding by. I think the key is to remain open, to look at things through different scopes and send different probes, to see every thought or idea as the equivalent of a NASA mission — an expanding and deepening expedition toward points of great magnetism, movement, and dimension. The stuff ancients compared with luck. Built gods around. Named planets after.

Each of us carry our own galaxies to traverse and investigate, to get excited about, free of charge. Lately, I try to mine my own mind-wanderings for light and opportunity, uncovering secrets below the crust of my exterior. What's in the solar system of my mind? What fascinating parts of myself and my thoughts do I have yet to explore? Astronomer John Scott Russell said, "Astronomy is the science of the harmony of infinite expanse." May each of you feel your exploration and expansion, and its vast worth.

Selena and Jess

Answers

SUDOKU #147

1	3	9	7	5	6	4	2	8
6	2	7	8	1	4	9	3	5
4	5	8	2	9	3	6	1	7
3	7	1	6	4	5	2	8	9
5	9	4	3	8	2	7	6	1
8	6	2	9	7	1	3	5	4
2	4	5	1	6	9	8	7	3
9	8	6	5	3	7	1	4	2
7	1	3	4	2	8	5	9	6

SUDOKU #148

9	5	4	8	1	7	2	6	3
1	3	6	2	9	5	8	4	7
8	2	7	3	4	6	5	9	1
7	1	9	6	5	4	3	2	8
6	4	3	7	2	8	9	1	5
2	8	5	1	3	9	4	7	6
3	7	8	9	6	2	1	5	4
4	9	1	5	7	3	6	8	2
5	6	2	4	8	1	7	3	9

Brainteasers

Page 7 Rebus Puzzle:
1. A big letdown
2. Rub the wrong way
3. An inside job

Send ideas and comments to:

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UNTIL NEXT TIME !